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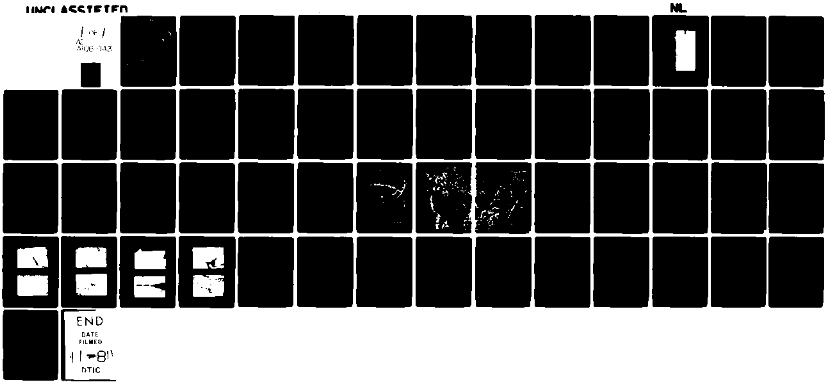

LEVEL II

UPPER MISSISSIPPI - SALT - QUINCY BASIN

AD A106043

HAFERS LAKE DAM

ST. CHARLES COUNTY, MISSOURI

MO 11118

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1980

UNCLASSIFIED

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

UPPER MISSISSIPPI - SALT - QUINCY BASIN

HAFERS LAKE DAM

ST. CHARLES COUNTY, MISSOURI

MO 11118

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Hafers Lake Dam, Mo. 11118 Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Hafers Lake Dam, Mo. 11118. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTAL BY: SIGNED — Chief, Engineering Division — 11 SEP 1980 Date

APPROVAL BY: SIGNED — Colonel, CE, District Engineer — 11 SEP 1980 Date

HAFERS LAKE DAM

MISSOURI INVENTORY NO. 11118

ST. CHARLES COUNTY, MISSOURI

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.

5200 OAKLAND AVENUE

ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

CORPS OF ENGINEERS

AUGUST 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Hafers Lake Dam
State Located:	Missouri
County Located:	St. Charles
Stream:	Tributary of Cole Creek
Date of Inspection:	18 April 1980

Hafers Lake Dam was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. Several animal burrows exist within the downstream face of the dam near the left abutment. Animal burrows can provide passageways for seepage that could develop into a piping condition (progressive internal erosion) resulting in failure of the dam.

2. Some minor erosion of unprotected areas of the excavated earth spillway exit channel particularly at the spillway crest, was observed. Although not considered to be serious at this time, continued erosion of the spillway channel could contribute to instability of the section as a result of loss of material at this location. Erosion of the spillway crest will also lower the normal operating level of the lake affecting the performance of the reservoir.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for Hafers Lake Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the fact that numerous dwellings lie within the possible flood damage zone, it is recommended that the spillway for this dam be designed for the PMF. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillway is capable, however, of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 90 percent of the PMF. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be one mile. Accordingly, within the possible damage zone are approximately twenty dwellings.

A review of available data did not disclose that seepage or stability analyses of this dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.

Harold B. Lockett

Harold B. Lockett
P. E. Missouri E-4189

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW PAPERS LAKE DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

HAFERS LAKE DAM - ID. NO. 11118

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

HAFERS LAKE DAM - I.D. NO. 11118

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Hafers Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the above dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Hafers Lake Dam is an earthfill type embankment rising approximately 27 feet above the original streambed. The embankment has an upstream slope (above the waterline) of 1v on 3.3h, a crest width of about 11 feet, and a downstream slope of 1v on 3.5h. The length of the dam is approximately 380 feet. A plan and profile of the dam are shown on Plate 3 and a cross-section of the dam is shown on Plate 4.

The spillway, an excavated earth section, is cut through the hillside ridge at the right or east abutment. The spillway outlet channel, a trapezoidal section protected by stone riprap through the exit section, joins the natural drainage course of the adjacent watershed at a point approximately 250 feet downstream of the spillway crest. This watercourse joins the tributary on which the dam is located at a point approximately 700 feet downstream of the dam. The dam has no emergency spillway or lake drawdown facility. A profile and cross-section of the spillway are shown on Plate 4.

The shoreline about the reservoir is exceptionally well kept with the lake banks and hillside slopes covered with grass. Several small-to-medium size trees are located about the lake. A small pond with a dam about 8 feet high and a surface area of approximately one acre is located immediately upstream from the lake. The pond serves to prevent silt and other foreign objects from entering the lake. At normal pool elevation the reservoir impounded by the dam occupies approximately 6 acres.

b. Location. The dam is located on an unnamed tributary of Cole Creek, about one mile west of the intersection of West Clay Street and First Capitol Drive within the City of St. Charles, Missouri, as shown on the Regional Vicinty Map, Plate 1. The dam is located in U.S. Survey 3280, approximately 15,600 feet northeast and 4,100 feet southeast of the northwest corner.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as small. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. Hafers Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends one mile downstream of the dam. Within the possible damage zone are approximately twenty dwellings. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e. <u>Ownership</u>. The lake and dam are owned by Charles W. Hafer. Mr. Hafer's address is: 1 Sun Valley, St. Charles, Missouri 63301.

f. <u>Purpose of Dam</u>. The dam impounds water for recreational use.

g. <u>Design and Construction History</u>. According to the Owner, the dam was constructed in 1955 by Mr. Robert Bright, a local earth moving contractor. The Owner observed that Mr. Bright is now living in Peel, Arkansas, having left the St. Charles area some time about 1965. Mr. Hafer reported that the dam was constructed without the benefit of any formal engineering studies or data although Mr. Bright had been at one time employed by the Missouri State Conservation Commission and was, based on his experience with the State Conservation Commission, familiar with the construction requirements and design techniques of earthen type dams.

h. <u>Normal Operational Procedure</u>. The lake level is unregulated. Lake outflow is governed by the capacity of an overflow type spillway.

1.3 PERTINENT DATA

a. <u>Drainage Area</u>. Two major urban streets, West Clay and Duchesne Drive, with numerous commerical establishments with paved parking lots fronting both sides of the streets, are located at the extreme southern and eastern limits of the watershed. Portions of a cemetery are located at the southwest corner of the drainage area. The balance of the watershed, with the exception of the Owner's residence and several out- buildings, is unimproved; however, it is well maintained and in a park-like condition. The watershed above the dam amounts to approximately 48 acres. The watershed area is outlined on Plate 2.

b. <u>Discharge at Damsite</u>.

(1) Estimated known maximum flood at damsite...120 cfs* (W.S. Elev. 522.2)
(2) Spillway capacity ...599 cfs (W.S. Elev. 524.0)

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on topographic data shown on the 1954 Kampville, MO-ILL Quadrangle Map, 7.5 Minute Series, photo revised 1974.

(1) Observed pool ... 521.2

(2) Normal pool ... 521.0

(3) Spillway Crest ... 521.0

(4) Maximum experienced pool ... 522.2*

(5) Top of Dam ... 524.0 (min.); 525.2 (max.)

(6) Streambed at centerline of dam ... 498±

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 521.0) ... 980 ft.

(2) Length at maximum pool (Elev. 524.0) ... 1,000 ft.

e. Storage.

(1) Normal pool ... 48 ac. ft.

(2) Top of Dam (incremental) ... 18 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 6 acres

(2) Top of dam (incremental) ... 1 acre

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier to the top of the dam.

* Based on an estimate of depth of flow at spillway as observed by the Owner.

(1) Type ... Earth fill, homogenous*

(2) Length ... 380 ft.

(3) Height ... 27 ft.

(4) Top width ... 11 ft.

(5) Side slopes

a. Upstream ... 1v on 3.3h (above waterline)

b. Downstream ... 1v on 3.5h

(6) Cutoff ... Clay core*

(7) Slope protection

a. Upstream ... Grass and stone riprap

b. Downstream ... Grass

h. Spillway.

(1) Type ... Uncontrolled, broad-crested, trapezoidal section

(2) Location ... Right abutment

(3) Crest ... Elevation 521.0

(4) Approach channel ... Lake

(5) Exit channel ... Earth cut, shallow trapezoidal section

i. Emergency Spillway . . . None

j. Lake Drawdown Facility . . . None

* Per Owner.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam are known to exist.

2.2 CONSTRUCTION

No formal records were maintained during construction of the dam. However, as previously stated, the dam was constructed in 1955 by a local earth moving contractor. According to Mr. Hafer, the Owner, a core trench about 10 feet wide and approximately 12 feet deep at the old stream bed, was excavated along the centerline of the dam using a D9 dozer. The trench was not carried to rock but was extended until good clay was encountered. Mr. Hafer also reported that the core trench was backfilled with selected clay like material obtained from the site hillsides and the area to be occupied by the lake, and that the trench backfill and the material in the dam was placed in about 12-inch layers and compacted by running the rubber-tired earth moving equipment over the fill. The Owner stated that approximately 5 or 6 years ago during a period when grading work was underway on the commercial property at the upper end of the watershed, excess earth from the grading operation was hauled to the dam and placed across the downstream face of the dam flattening the slope.

2.3 OPERATION

The lake level is uncontrolled and governed by the crest elevation of the excavated earth spillway located at the right abutment. The Owner reported that the dam has never been overtopped and that the maximum flood experienced by the dam occurred in April of 1979 when discharge from the lake produced a depth of flow at the spillway estimated to be about 14 inches.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were unavailable.

b. <u>Adequacy</u>. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Hafers Lake Dam was made by Horner & Shifrin engineering personnel, H. B. Lockett, Civil Engineer and Hydrologist, and A. B. Becker, Jr., Civil and Soils Engineer, on 18 April 1980. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the site geology. Also examined at the time of the inspection, were the area and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on Pages A-1 through A-4 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The dam site is located near the northern edge of the Ozark Uplift Physiographic Province, near the border with the Dissected Till Plains Section of the Central Lowlands Province. The bedrock formations consist of gently northward dipping Mississippian age sedimentary strata. No specific outcrops were noted at the site; however, outcrops in the general vicinity indicate the area is underlain by the St. Louis Limestone. No faults were observed or are reported to be present in this area.

The St. Louis Limestone is a light colored, dense, crystalline limestone that is usually thickly or massively bedded. The bedrock is highly susceptible to solution, and sinkholes, caves and solution enlarged joints or bedding planes frequently occur. The contact between the bedrock and the overlying surficial material is usually irregular and bedrock remnants in the residual material are common.

The bedrock surface is overlain by a thick deposit of Menfro Series soils, derived from loessal deposits. This series consists of deep, well drained soils formed from the wind deposited silts on ridgetops and hillsides adjacent to the Missouri River Valley. It is a dark-yellowish brown friable silt in the upper layers, becoming darker and more clayey with depth. It is relatively permeable material, highly subject to erosion but generally

suitable for embankment materials and reservoir impoundments. According to the Unified Soil Classification System, the soils are classifed CL or CL-ML materials. Although not observed, these soils are usually underlain by the red, blocky residual clay formed as residuum from the weathering of limestone bedrock.

There appear to be no significant geotechnical problems at the dam site. No adverse geologic conditions were observed that would be considered conducive to severe reservoir leakage or embankment stability.

c. Dam. The visible portions of the upstream and downstream faces of the dam as well as the dam crest (see Photos 1 and 2) were examined and appeared for the most part to be in sound condition. However, 6 animal burrows (see Photo 7) that according to the Owner were made by groundhogs, were observed in the downstream face of the dam about 10 feet below the crest near the left abutment. No cracking of the dam surface, settlement of the dam, or sloughing of the dam slopes was noticed, nor was there any seepage evident in the immediate area downstream of the dam. Cattails and willow trees (see Photo 5) were observed growing along the course of the old streambed at a point beginning about 200 feet downstream of the dam. According to the Owner, a small spring, which existed prior to construction of the dam is located within the stream channel at about this point. No flow was noticed within the streambed at this location; however, the ground was soft and wet.

The upstream face of the dam is adequately protected against erosion by stone riprap that extends along the dam face from about 1 foot above the normal pool level to approximately 2 feet below the normal waterline. At the surface the riprap consists of limestone about 2 inches and smaller in size. According to the owner, the 2-inch size stone overlies larger, quarry-run size, limestone. A pole type retaining wall approximately 2.5 feet high serves to prevent downward movement or displacement of the stone. According to the Owner, the retaining wall consists of three wood telephone type poles placed horizontally one above another retained by wood poles installed vertically in the face of the dam at about 20 foot centers. Judging by the alignment of the top of the wall which was submerged about 2 feet at the time

of the inspection, the wall appeared to be stable and in good condition. Remaining areas of the dam were protected by a substantial cover of grass that was about 3 inches high at the time of the inspection. A sample of soil obtained from the surface of the downstream face of the embankment about 10 feet below the crest and near the center of the dam indicated that the material was a silty lean clay (CL) of low-to-medium plasticity. Presumably, the soil sample was from the material added to the embankment in about 1974.

The excavated earth spillway was thoroughly covered with grass (see Photo 3) through the crest section. Limestone riprap up to about 12 inches in size that serves to protect the spillway exit section (see Photo 4) did not uniformly cover the entire channel area and several small gulleys, up to about 12 inches in depth (see Photo 8) were observed within the section. The spillway channel below the exit section (see Photo 4) was unprotected and some minor erosion of the unconfined waterway was evident.

d. Appurtenant Structures. There are no appurtenant structures at this dam.

e. Downstream Channel. The channel downstream of the dam is unimproved for a distance of approximately 1,800 feet at which point flow enters an 84-inch diameter pipe and is confined within the pipe for a distance of about 1,700 feet. Flow leaving the pipe after having passed through a residential subdivision joins Cole Creek at a point approximately 200 feet upstream of the Droste Road bridge crossing.

f. Reservoir. The area adjacent to the lake is exceptionally well kept with the lake banks and hillside slopes covered with grass. Telephone type poles placed horizontally and concrete curb walls surround the lake at the normal waterline. As previously mentioned, a small pond located just upstream of the reservoir serves to prevent silt and other foreign matter from entering the lake. In 1979 the Owner excavated material from the lake bottom near the shoreline at the upper end of the lake. Piles of excavated material were observed adjacent to the southeast end of the lake at the time of the inspection. The amount of sediment remaining in the lake could not be determined; however, it is believed to be hydraulically insignificant.

3.2 EVALUATION

With the exception of the animal burrows that are present within the downstream face of the dam, the deficiencies observed during the inspection and noted herein, are not considered of significant importance to warrant immediate remedial action. The Owner is advised to rid the dam of burrowing animals and to restore the embankment to sound condition without delay.

According to the Owner, the spring located some 200 feet downstream of the dam existed prior to construction of the dam; however, it is recommended that flow from the spring be monitored for sudden increases in volume and/or turbidity, which are indications that the dam may be experiencing a piping condition.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

With the exception of several animal burrows that are present in the downstream face of the dam, the inspection team is of the opinion that the dam is well maintained.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Regular maintenance of dam features is considered beneficial to the overall safety of a dam. The Owner should without delay take whatever measures necessary to rid the dam of burrowing animals and to restore the embankment to sound condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design of Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were determined from the 1954 USGS Kampville, Missouri-Illinois Quadrangle Map. The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection. Records of rainfall, streamflow, or flood data for the watershed were not available.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends one mile downstream of the dam. At a point approxiately 1,800 feet downstream of the dam, flow leaving the downstream channel is confined within an 84-inch diameter pipe. The outlet end of the pipe joins Cole Creek approximately 3,500 feet downstream of the dam.

c. Visual Observations.

(1) The spillway consists of a trapezoidal section cut into the hillside at the right abutment.
(2) The spillway exit channel directs flow away from the toe of the embankment. Spillway releases within the capacity of the spillway section will not endanger the dam.
(3) The dam has no emergency spillway.
(4) No lake drawdown facilities are provided.
(5) A small pond, with a dam about 8 feet high and a surface area of approximately 1 acre is located immediately upstream of the lake. Because of its small size and limited storage capacity, this pond was not considered to be of hydrologic significance and was disregarded in the overtopping analysis.
(6) Two small islands are located in the lake. These islands were disregarded in computing the storage capacity of the lake.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood without overtopping the dam. The spillway is adequate, however, to pass 1/2 the probable maximum flood without overtopping the dam. The results of the dam overtopping analyses are as follows:

(Note: The data appearing in the following table has been extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max Lake W.S. Elev.	Max. Depth of Flow over Dam (Elev. 524.0)	Duration of Overtopping of Dam (Hours)
0.50	302	523.0	0	0
1.00	718	524.3	0.3	0.3

Elevation 524.0 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be approximately 599 cfs, which is the routed outflow corresponding to about 90 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 0.3 feet and overtopping will extend for approximately 25 feet along the dam at the right abutment and for about 15 feet at the left abutment.

e. Evaluation of Overtopping Effect. For the PMF condition the depth of flow and the duration of flow overtopping the dam are minor, 0.3 feet and 0.3 hours respectively. In addition the dam crest and downstream face are protected by a substantial cover of turf that is expected to prevent any serious erosion during this event. Therefore, structural damage to the dam due to overtopping is expected to be negligible.

f. References. Procedures and data for determining the probable maximum flood, the 1 percent chance (100-year frequency) flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on

Pages B-1 and B-2 of Appendix B. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year frequency flood are shown on pages B-3 through B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10; and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-10.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. With the exception of the animal burrows that are present in the downstream face of the dam near the left abutment, there were no conditions observed during the visual inspection which adversely affect the structural stability of the dam.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not avaialble, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam.

d. Post Construction Changes. Except for the addition of the fill material to the back side of the dam (no record of the original dam section or quantity of fill placed is known to exist) approximately 5 or 6 years ago, and the construction of the wood pole retaining wall across the upstream face of the dam, the Owner reported that no additional post construction changes have been made or have occurred that would affect the structural stability of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic area. An earthquake of this magnitude would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the spillway is capable of passing lake outflow of about 599 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 718 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 94 cfs.

The only item noticed during the visual inspection that could adversely affect the safety of the dam is the presence of several animal burrows within the downstream face of the dam near the left abutment.

Seepage and stability analyses of the dam were not available for review and therefore no judgment could be made with respect to the structural stability of the dam.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessment of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. Except as noted herein, the remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a, should be accomplished sometime in the near future. The Owner is advised to rid the dam of burrowing animals and to restore the embankment to sound condition without delay.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic area. An earthquake of this magnitude would not be expected to cuase structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased to pass lake outflow resulting from a storm of probable maximum flood magnitude; in any event, the spillway should be protected against erosion.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of dams. The presence of the pole type retaining wall that serves to support the stone riprap across the upstream face of the dam should be taken into consideration when stability analyses are made.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

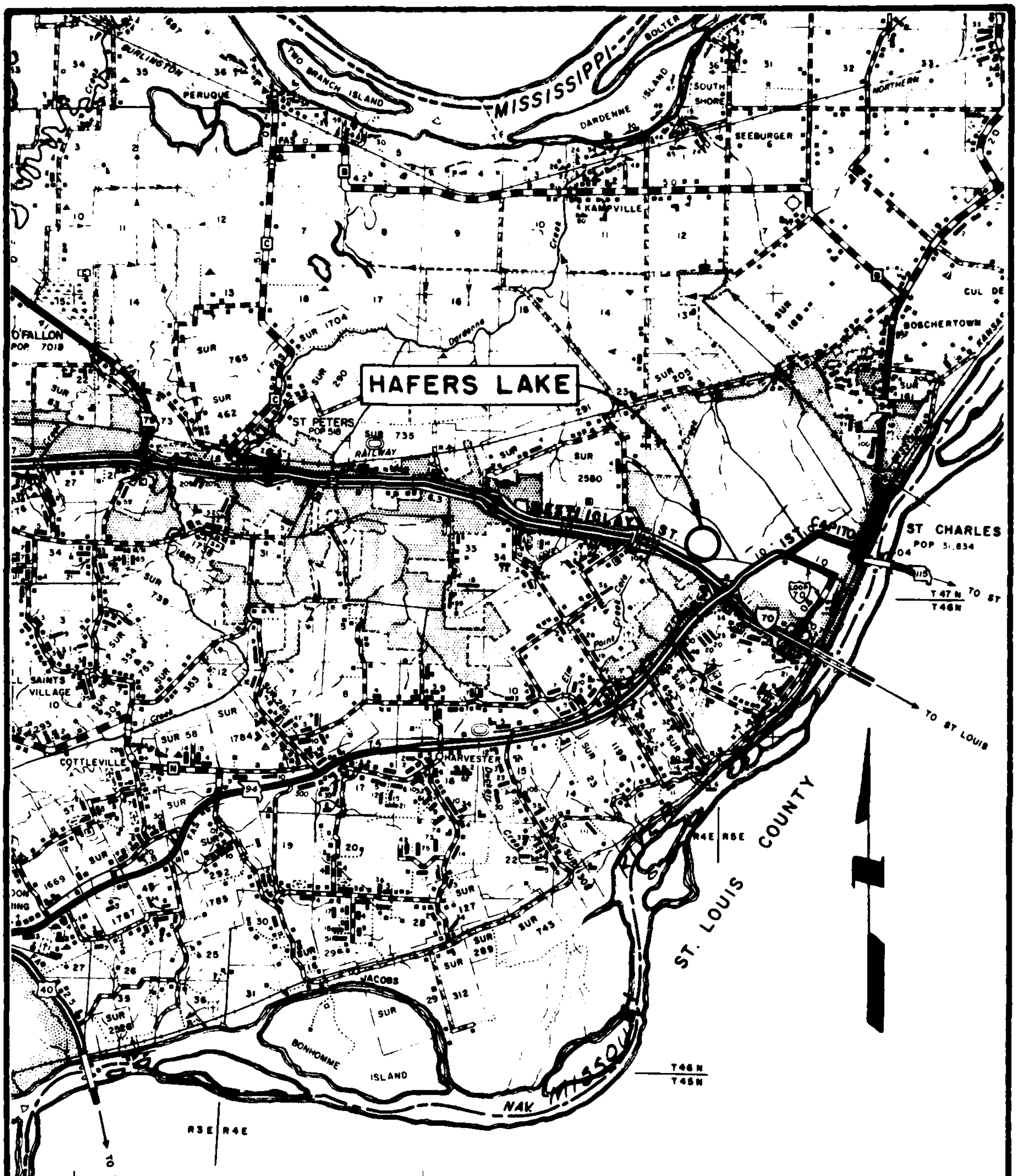
(1) Rid the dam of burrowing animals and restore the embankment to sound condition. An animal burrow can provide a passageway for lake seepage that could lead to a piping condition (progressive internal erosion) and subsequent failure of the dam.

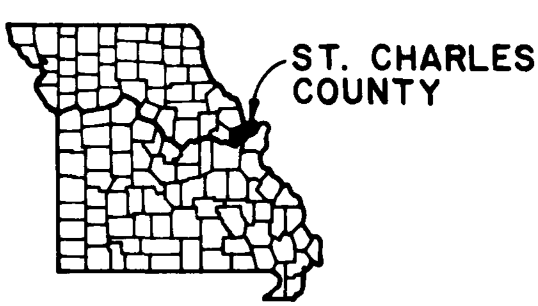
(2) Restore the eroded areas of the spillway exit channel and provide some form of protection to prevent future erosion by lake outflow. Continued erosion of the spillway channel could contribute to instability of the section as a result of loss of material at this location. Erosion of the

spillway crest will also lower the normal operating level of the lake affecting the performance of the reservoir.

(3) Monitor flow from the spring downstream of the dam for sudden increases of volume and/or turbidity, which are indications that the dam may be experiencing a piping condition.

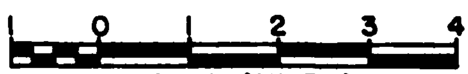
(4) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.





LOCATION MAP

HAFERS LAKE



REGIONAL VICINITY MAP

PLATE 1


A = APPROXIMATE EXTENT OF
DOWNSTREAM DAMAGE DONE
COLE
CREEK
A

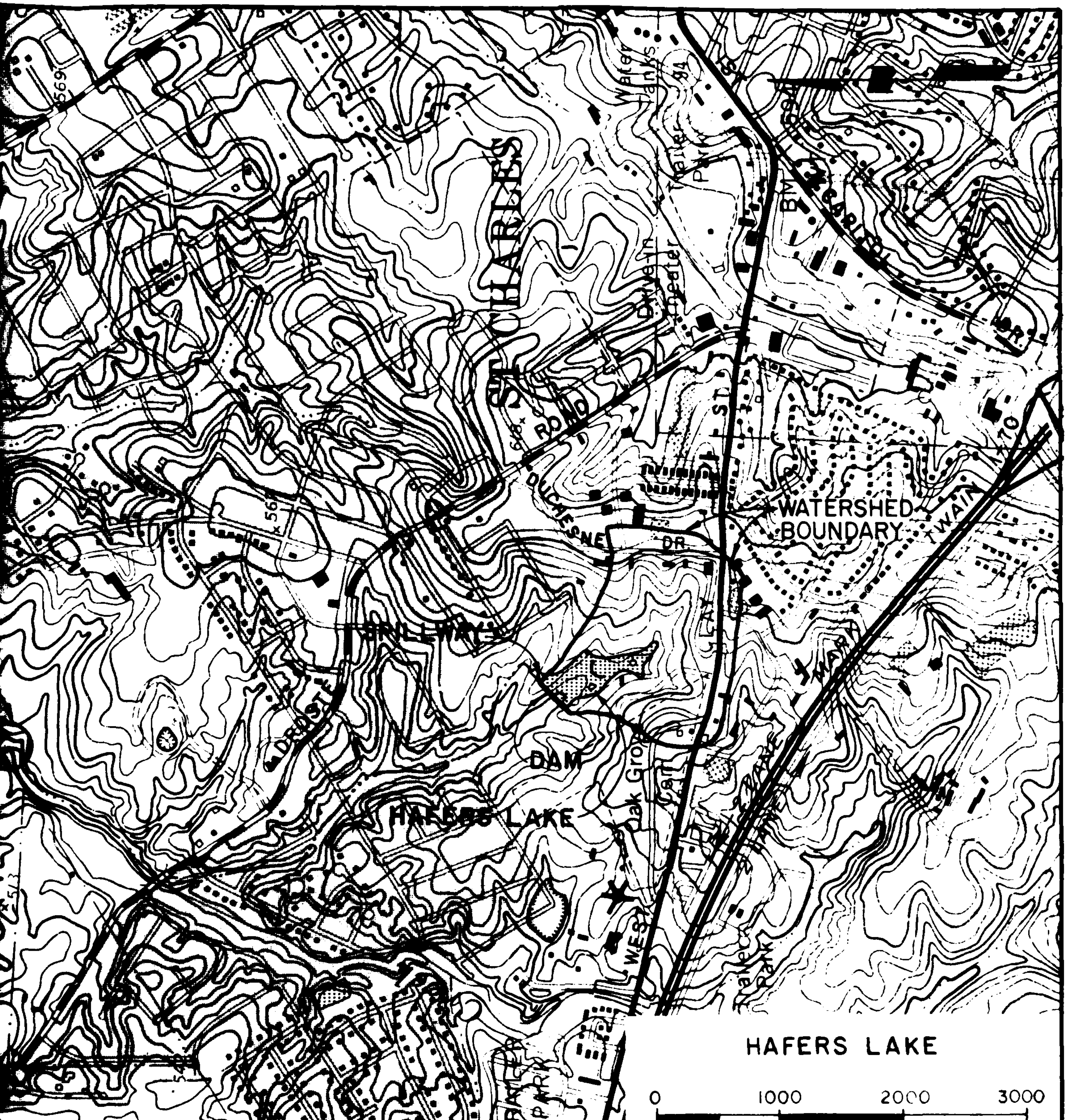
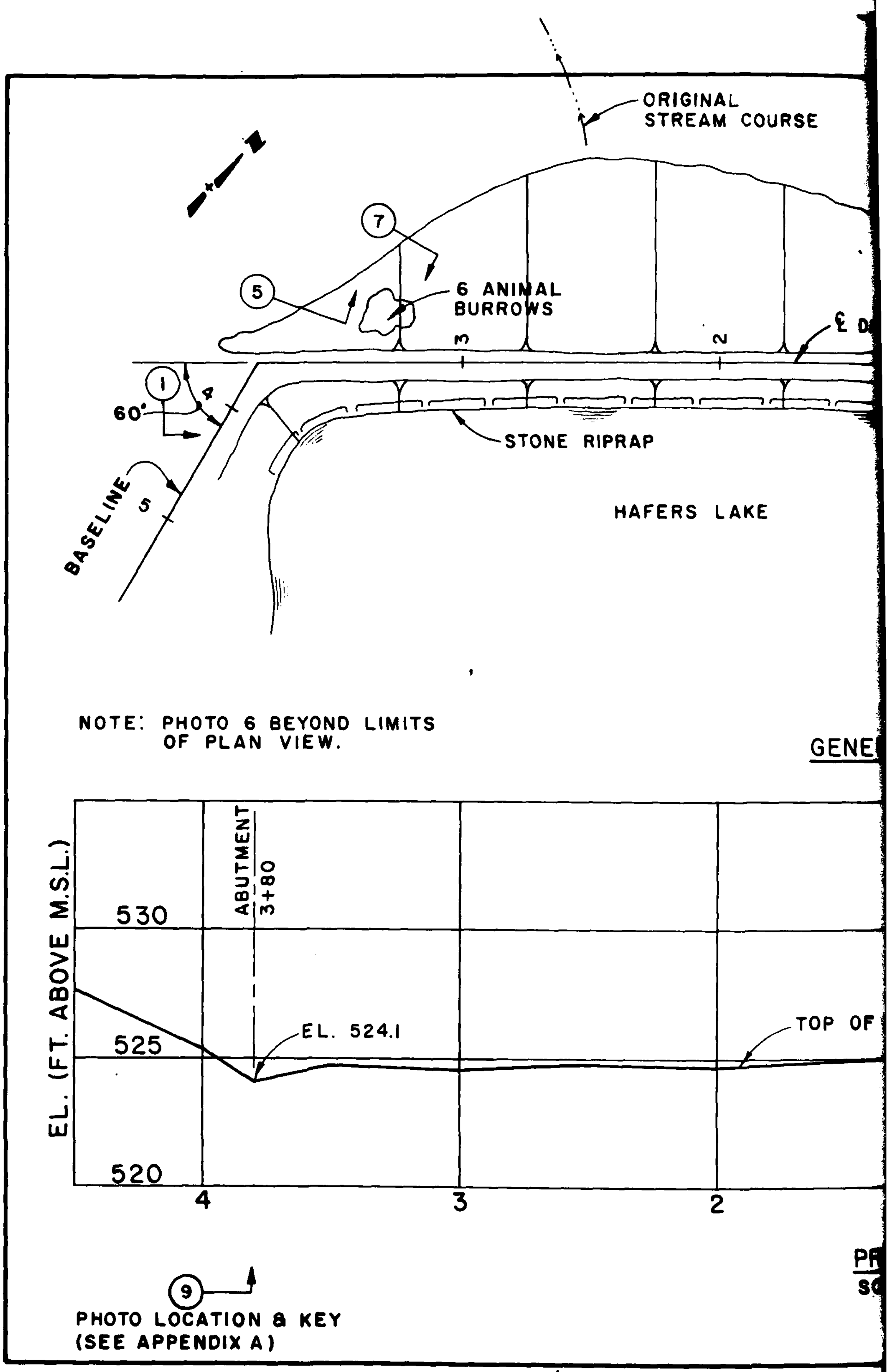
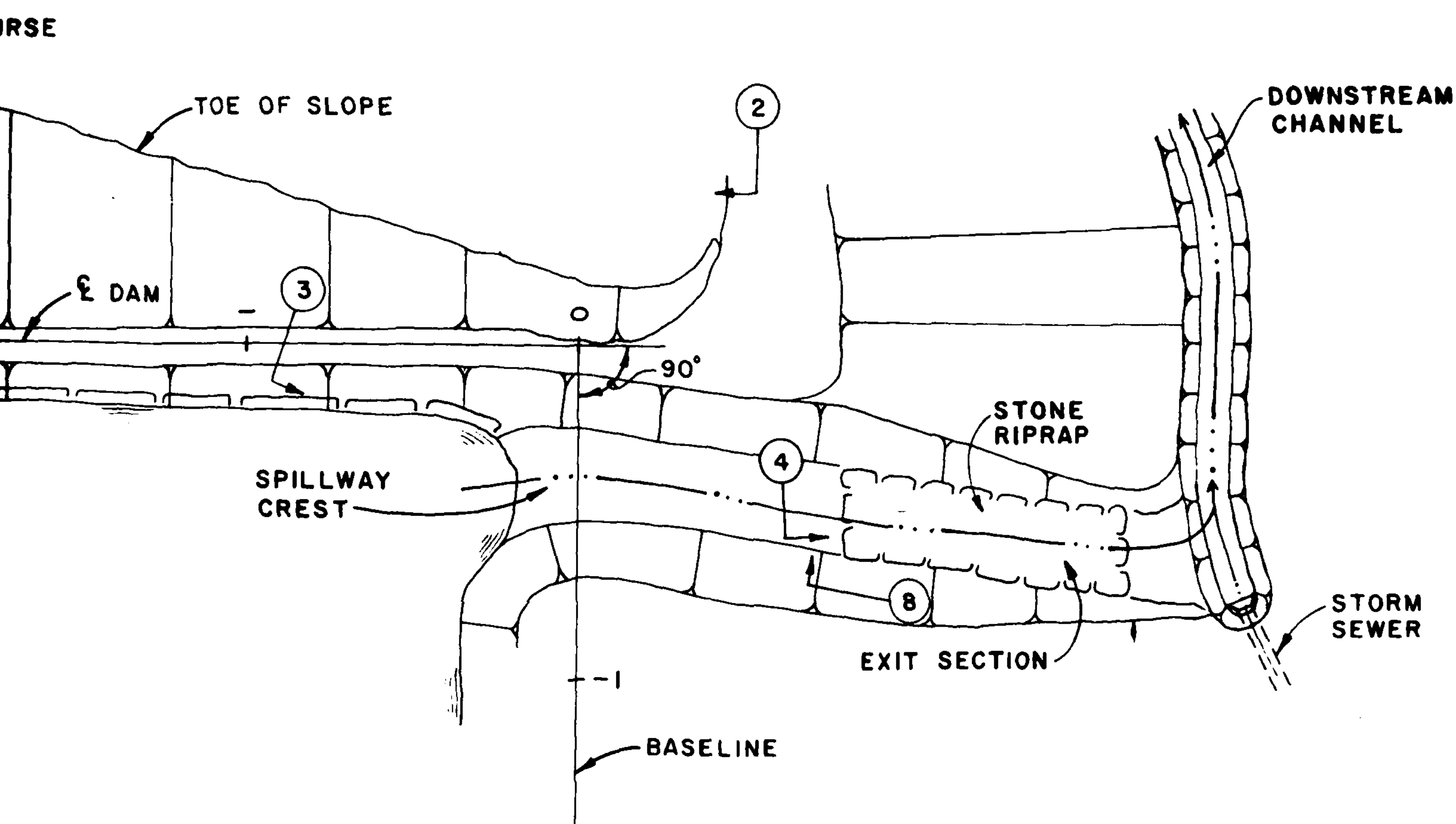

WATERSHED BOUNDARY
SPILLWAY
DAM
HAFERS LAKE
DUQUESNE DR.
ROAD
HAFERS LAKE
0 1000 2000 3000
SCALE IN FEET
(CONTOUR INTERVAL 10 FEET)
LAKE WATERSHED MAP

PLATE 2

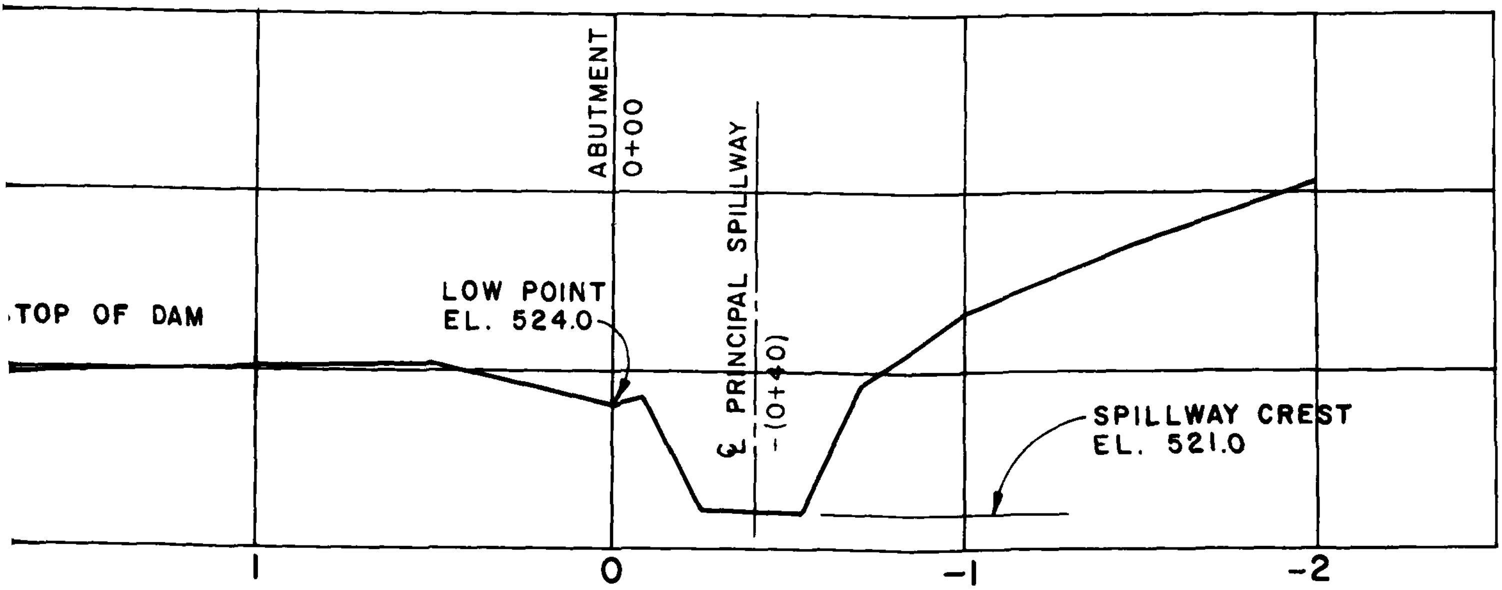


ORIGINAL
STREAM COURSE
7
5
6 ANIMAL
BURROWS
3
2
1
4
60°
5
BASELINE
STONE RIPRAP
HAFERS LAKE
NOTE: PHOTO 6 BEYOND LIMITS
OF PLAN VIEW.
GENE
ABUTMENT
3+80
EL. (FT. ABOVE M.S.L.)
530
525
520
EL. 524.1
TOP OF
4
3
2
PR
SC
9
PHOTO LOCATION & KEY
(SEE APPENDIX A)



GENERAL PLAN OF DAM

SCALE: 1"=50'



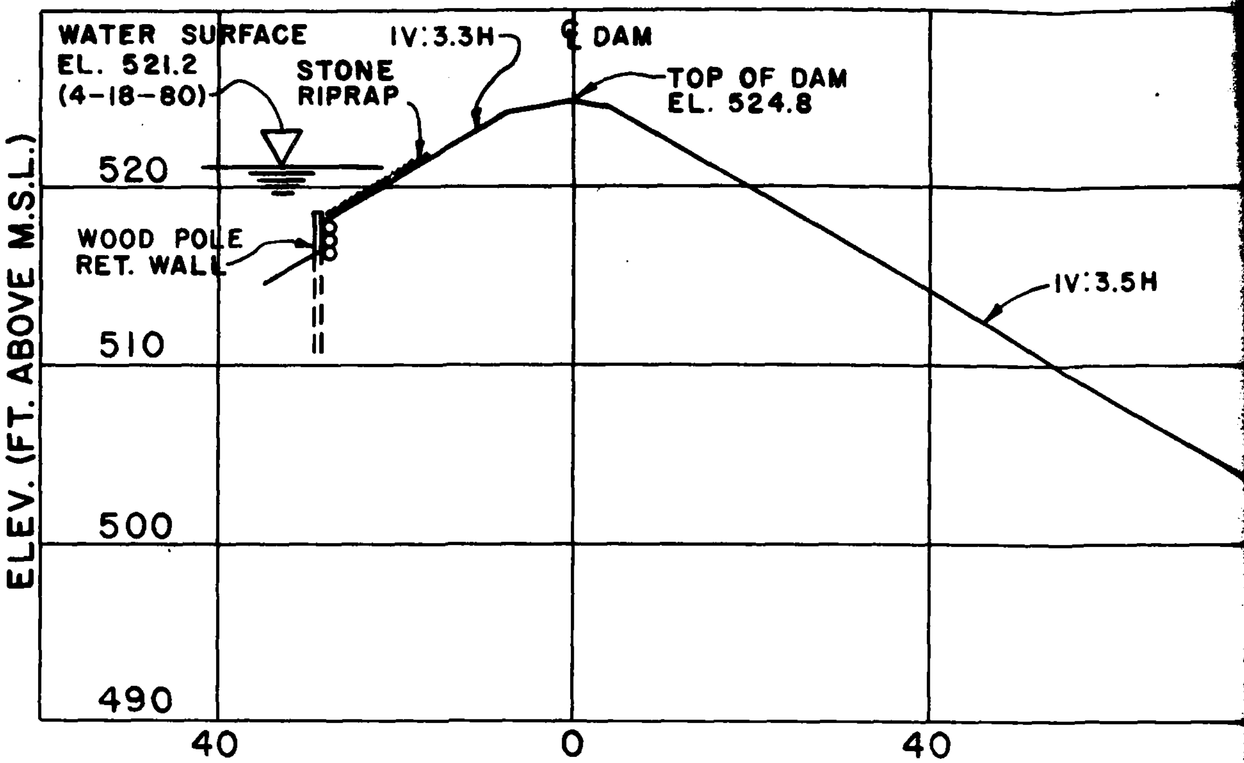
PROFILE DAM CREST

SCALE: 1"=5'V., 1"=50'H.

HAFERS LAKE
DAM PLAN & PROFILE

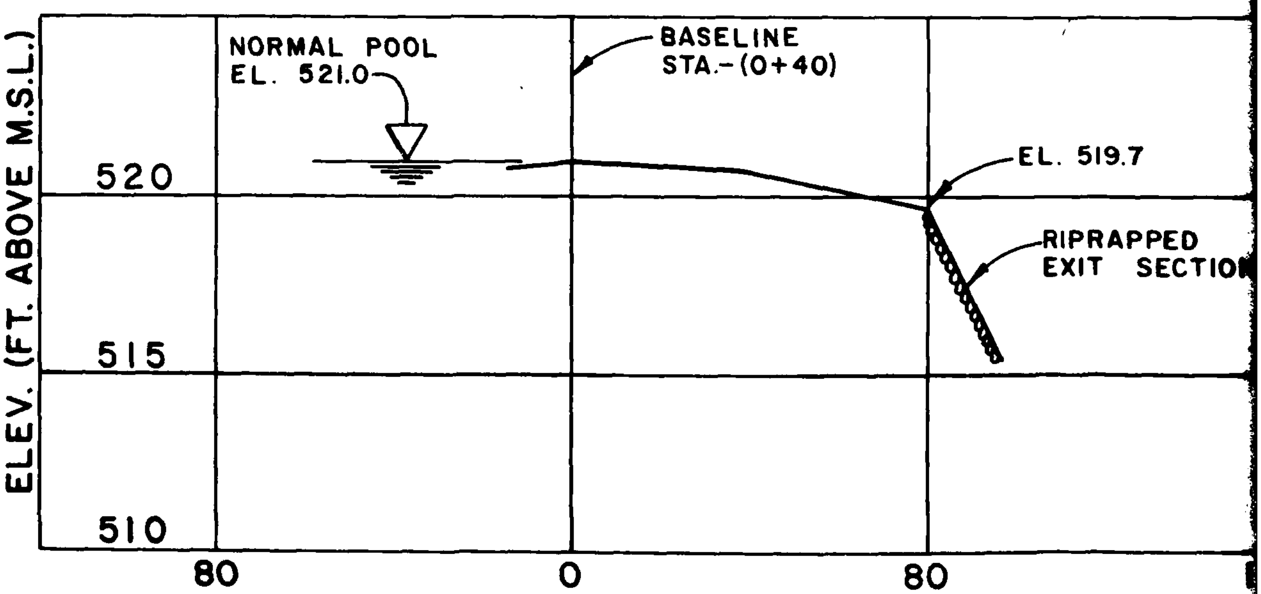
Horner & Shifrin, Inc. May 1980

PLATE 3



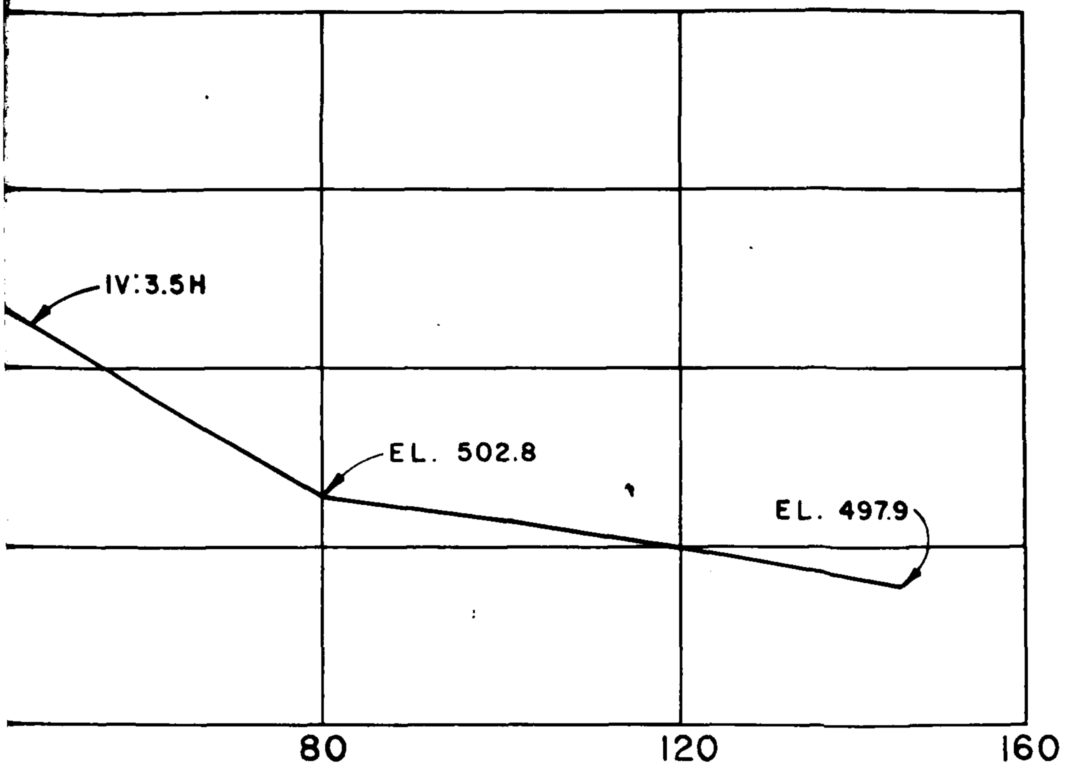
DAM CROSS-SECTION STA. 2+

SCALE: 1"=10'V., 1"=20'H.

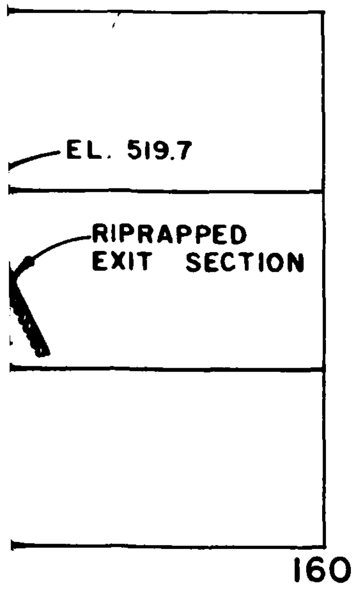


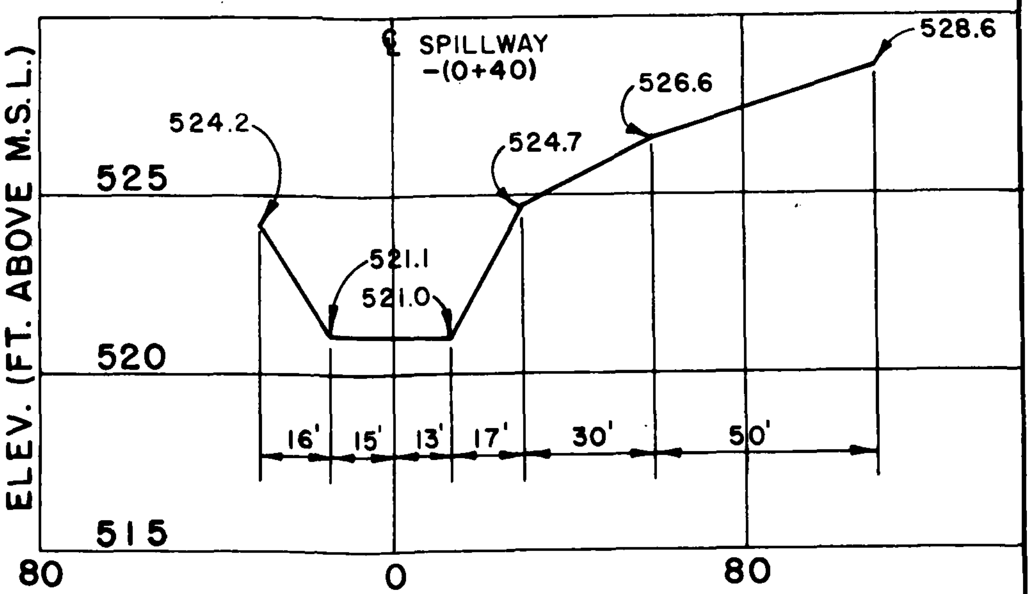
PROFILE SPILLWAY ℄

SCALE: 1"=5'V., 1"=40'H.



ECTION STA. 2+50
"=10'V., I"=20'H.





SPILLWAY CROSS-SECTION
SCALE: I"=5'V., I"=40'H.

HAFERS LAKE
DAM CROSS-SECTION
SPILLWAY PROFILE & SECTION
Horner & Shifrin, Inc. May 1980

APPENDIX A

INSPECTION PHOTOGRAPHS

NO. 1: DAM CREST & UPSTREAM FACE OF DAM

NO. 2: DOWNSTREAM FACE OF DAM

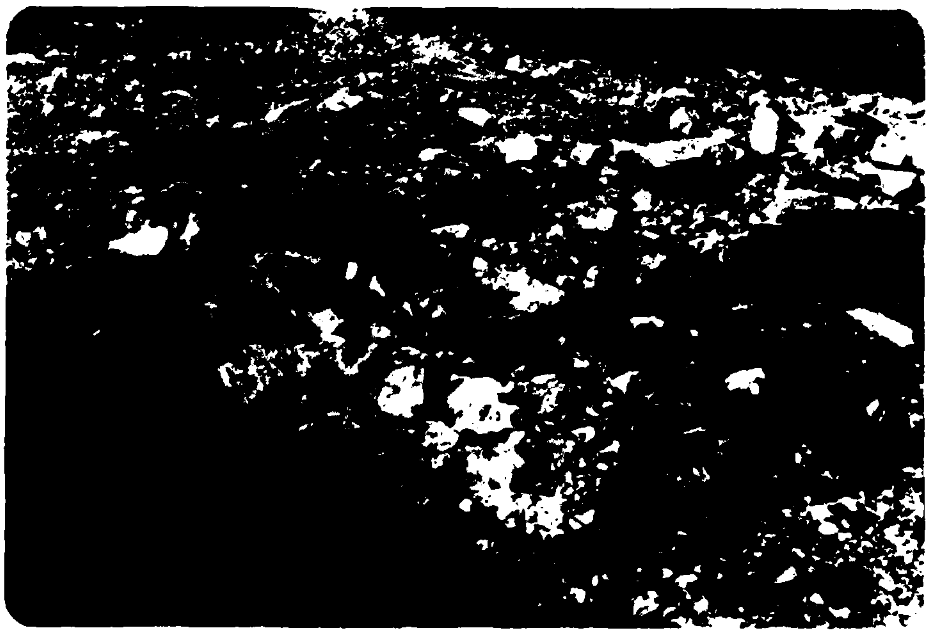
NO. 3: SPILLWAY CREST

NO. 4: SPILLWAY EXIT CHANNEL

NO. 5: ORIGINAL STREAM COURSE DOWNSTREAM OF DAM

NO. 6: SMALL DAM & OUTLET PIPE AT UPSTREAM END OF LAKE

NO. 7: ANIMAL BURROW IN DOWNSTREAM FACE OF DAM



NO. 8: EROSION AT SPILLWAY EXIT CHANNEL

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping anlyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (22 sq. mile, 24-hour value equals 25.0 inches) from Hydrometerological Report No. 33. The precipitation data used in the analysis of the 1 percent chance (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers. Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

b. Drainage area = 0.075 square miles = 48 acres.

c. SCS parameters:

Lag Time = 0.60 (T_c) = 0.038 hours

Soil Group = B (100 percent Menfro Series per SCS County Soil Report)

Soil type CN = 78 (AMC III, PMF condition)

= 61 (AMC II, 100-yr condition)

Time of Concentration (T_c) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.063 hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours

L = Length of longest watercourse = 0.180 miles

H = Elevation difference = 91 feet

The time of concentration (T_c) was obtained using Method C as described in Figure 30, "Design of Small Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

2. The spillway section consists of a broad-crested, trapezoidal section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (area, "a" and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth was computed as $Qc = \left(\frac{a^3 g}{t}\right)^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas. Reference, "Handbook of Hydraulics", Fifth Edition, King and Brater, page 8-7.

c. Static lake levels corresponding to the various values passing the spillway were computed as critical depths plus critical velocity head ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

d. Spillway discharge values for equal elevations were selected for entry on the Y4 and Y5 cards.

3. The profile of the dam crest is irregular and flow over the dam cannot be determined by conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and the $V cards. The program computes internally the flow over the dam crest and adds this flow to the flow over the spillway as entered on the Y4 and Y5 cards.

```
A1      ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HAFERS LAKE DAM
A3      RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5       0       0       0       0       0       0       0
B1      5
J       1       3       1
J1   0.50    0.90    1.00
K       0  INFLOW                                       1
K1      INFLOW HYDROGRAPH
M       1       2   0.075                   1.0                             1
P       0    25.0     102     120     130
T                                                      -1     -78            0.404
W2          0.038
X    -1.0    -.10     2.0
K       1     DAM                                       1
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                           48.32      -1
Y4  521.0   521.7   522.4   523.1   523.8   524.4   525.1   525.4   526.1   526.4
Y4  527.0   527.6   528.3   528.7   529.3   529.8   530.5
Y5      0    50.0   160.6   316.7     517     762    1052    1183    1561    1769
Y5   2163    2621    3261    3686    4308    5033    6045
$A      0     5.5     9.2    13.8    20.2    26.6
$E494.64     521     530     540     550     560
$$ 521.0
$D 524.0
$L      0       4      54     114     249     341     397     450     500     550
$V  524.0   524.1   524.6   524.7   524.8   525.1   525.2   527.7   529.7   531.5
K      99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HAFERS LAKE DAM
A3       100-YR FLOOD ROUTED THROUGH RESERVOIR
B      288       0       5                                       4
B1       5
J        1       1       1
J1    1.00
K        0  INFLOW                                       1
K1          INFLOW HYDROGRAPH
M        0       2   0.075                     1.0                       1
O      288   6.974
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .023    .023
O1    .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
O1    .023    .023    .023    .023    .023    .023    .030    .030    .030    .030
O1    .030    .030    .048    .048    .048    .049    .049    .049    .134    .134
O1    .134    .255    .255    .546    .817    .380    .255    .134    .134    .134
O1    .049    .049    .049    .048    .048    .048    .030    .030    .030    .030
O1    .030    .030    .023    .023    .023    .023    .023    .023    .023    .023
O1    .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1    .012    .012    .012    .012    .012    .012    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .077    .007    .007    .007
T                                                       -1     -61           0.404
W2           0.038
X     -1.0    -.10     2.0
K        1     DAM                                       1
```

100-YR. FLOOD (con't.)

```
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                               48.32      -1
Y4  521.0   521.7   522.4   523.1   523.8   524.4   525.1   525.4   526.1   526.4
Y4  527.0   527.6   528.3   528.7   529.3   529.8   530.5
Y5      0    50.0   160.6   316.7     517     762    1052    1183    1561    1769
Y5   2163    2621    3261    3686    4308    5033    6045
$A      0     5.5     9.2    13.8    20.2    26.6
$E494.64      521     530     540     550     560
$$  521.0
$D  524.0
$L      0       4      54     114     249     341     397     450     500     550
$V  524.0   524.1   524.6   524.7   524.8   525.1   525.2   527.7   529.7   531.5
K      99
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HAFERS LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 3 LRTIO= 1
RTIOS= .50 .90 1.00

****

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.08	0.00	.08	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-78.00	0.00	.40

CURVE NO = -78.00 WETNESS = -1.00 EFFECT CN = 78.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .04

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .04 VOL= 1.00
431. 121. 24. 5. 0.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.01	.01	2.	1.01	12.05	145	.21	.20	.02	93.
1.01	.10	2	.01	.01	.01	3.	1.01	12.10	146	.21	.20	.02	110.
1.01	.15	3	.01	.01	.01	3.	1.01	12.15	147	.21	.20	.01	114.
1.01	.20	4	.01	.01	.01	3.	1.01	12.20	148	.21	.20	.01	115.
1.01	.25	5	.01	.01	.01	3.	1.01	12.25	149	.21	.20	.01	116.
1.01	.30	6	.01	.01	.01	3.	1.01	12.30	150	.21	.20	.01	116.
1.01	.35	7	.01	.01	.01	3.	1.01	12.35	151	.21	.20	.01	116.
1.01	.40	8	.01	.01	.01	3.	1.01	12.40	152	.21	.20	.01	117.
1.01	.45	9	.01	.01	.01	3.	1.01	12.45	153	.21	.20	.01	117.
1.01	.50	10	.01	.01	.01	3.	1.01	12.50	154	.21	.20	.01	117.
1.01	.55	11	.01	.01	.01	3.	1.01	12.55	155	.21	.20	.01	117.
1.01	1.00	12	.01	.01	.01	3.	1.01	13.00	156	.21	.20	.01	118.
1.01	1.05	13	.01	.01	.01	3.	1.01	13.05	157	.26	.24	.01	135.
1.01	1.10	14	.01	.01	.01	3.	1.01	13.10	158	.26	.24	.01	141.
1.01	1.15	15	.01	.01	.01	3.	1.01	13.15	159	.26	.24	.01	142.
1.01	1.20	16	.01	.01	.01	3.	1.01	13.20	160	.26	.25	.01	142.
1.01	1.25	17	.01	.01	.01	3.	1.01	13.25	161	.26	.25	.01	143.
1.01	1.30	18	.01	.01	.01	3.	1.01	13.30	162	.26	.25	.01	143.
1.01	1.35	19	.01	.01	.01	3.	1.01	13.35	163	.26	.25	.01	143.
1.01	1.40	20	.01	.01	.01	3.	1.01	13.40	164	.26	.25	.01	143.
1.01	1.45	21	.01	.01	.01	3.	1.01	13.45	165	.26	.25	.01	143.
1.01	1.50	22	.01	.01	.01	3.	1.01	13.50	166	.26	.25	.01	144.
1.01	1.55	23	.01	.01	.01	3.	1.01	13.55	167	.26	.25	.01	144.
1.01	2.00	24	.01	.01	.01	3.	1.01	14.00	168	.26	.25	.01	144.
1.01	2.05	25	.01	.01	.01	3.	1.01	14.05	169	.32	.31	.01	171.
1.01	2.10	26	.01	.01	.01	3.	1.01	14.10	170	.32	.31	.01	179.
1.01	2.15	27	.01	.01	.01	3.	1.01	14.15	171	.32	.31	.01	180.
1.01	2.20	28	.01	.01	.01	3.	1.01	14.20	172	.32	.31	.01	181.
1.01	2.25	29	.01	.01	.01	3.	1.01	14.25	173	.32	.31	.01	181.
1.01	2.30	30	.01	.01	.01	3.	1.01	14.30	174	.32	.31	.01	181.
1.01	2.35	31	.01	.01	.01	3.	1.01	14.35	175	.32	.31	.01	181.
1.01	2.40	32	.01	.01	.01	3.	1.01	14.40	176	.32	.31	.01	181.
1.01	2.45	33	.01	.01	.01	3.	1.01	14.45	177	.32	.31	.01	182.
1.01	2.50	34	.01	.01	.01	3.	1.01	14.50	178	.32	.31	.01	182.
1.01	2.55	35	.01	.01	.01	3.	1.01	14.55	179	.32	.31	.01	182.
1.01	3.00	36	.01	.01	.01	3.	1.01	15.00	180	.32	.31	.01	182.
1.01	3.05	37	.01	.01	.01	3.	1.01	15.05	181	.19	.19	.00	129.
1.01	3.10	38	.01	.01	.01	3.	1.01	15.10	182	.39	.38	.01	197.
1.01	3.15	39	.01	.01	.01	3.	1.01	15.15	183	.39	.38	.01	217.
1.01	3.20	40	.01	.01	.01	3.	1.01	15.20	184	.58	.57	.01	303.
1.01	3.25	41	.01	.01	.01	3.	1.01	15.25	185	.68	.67	.01	369.
1.01	3.30	42	.01	.01	.01	3.	1.01	15.30	186	1.65	1.63	.02	798.
1.01	3.35	43	.01	.01	.01	3.	1.01	15.35	187	2.71	2.69	.03	1374.
1.01	3.40	44	.01	.01	.01	3.	1.01	15.40	188	1.07	1.06	.01	822.
1.01	3.45	45	.01	.01	.01	3.	1.01	15.45	189	.68	.67	.01	490.
1.01	3.50	46	.01	.01	.01	3.	1.01	15.50	190	.58	.58	.00	368.
1.01	3.55	47	.01	.01	.01	4.	1.01	15.55	191	.39	.38	.00	257.
1.01	4.00	48	.01	.01	.01	4.	1.01	16.00	192	.39	.39	.00	229.
1.01	4.05	49	.01	.01	.01	4.	1.01	16.05	193	.30	.30	.00	186.
1.01	4.10	50	.01	.01	.01	4.	1.01	16.10	194	.30	.30	.00	174.

PMF END-OF-PERIOD FLOW

1.01	4.15	51	.01	.01	.01	4.	1.01	16.15	195	.30	.30	.00	172.
1.01	4.20	52	.01	.01	.01	4.	1.01	16.20	196	.30	.30	.00	172.
1.01	4.25	53	.01	.01	.01	4.	1.01	16.25	197	.30	.30	.00	172.
1.01	4.30	54	.01	.01	.01	4.	1.01	16.30	198	.30	.30	.00	172.
1.01	4.35	55	.01	.01	.01	4.	1.01	16.35	199	.30	.30	.00	172.
1.01	4.40	56	.01	.01	.01	4.	1.01	16.40	200	.30	.30	.00	172.
1.01	4.45	57	.01	.01	.01	4.	1.01	16.45	201	.30	.30	.00	172.
1.01	4.50	58	.01	.01	.01	4.	1.01	16.50	202	.30	.30	.00	172.
1.01	4.55	59	.01	.01	.01	4.	1.01	16.55	203	.30	.30	.00	172.
1.01	5.00	60	.01	.01	.01	4.	1.01	17.00	204	.30	.30	.00	172.
1.01	5.05	61	.01	.01	.01	4.	1.01	17.05	205	.23	.23	.00	144.
1.01	5.10	62	.01	.01	.01	4.	1.01	17.10	206	.23	.23	.00	137.
1.01	5.15	63	.01	.01	.01	4.	1.01	17.15	207	.23	.23	.00	135.
1.01	5.20	64	.01	.01	.01	4.	1.01	17.20	208	.23	.23	.00	135.
1.01	5.25	65	.01	.01	.01	4.	1.01	17.25	209	.23	.23	.00	135.
1.01	5.30	66	.01	.01	.01	4.	1.01	17.30	210	.23	.23	.00	135.
1.01	5.35	67	.01	.01	.01	4.	1.01	17.35	211	.23	.23	.00	135.
1.01	5.40	68	.01	.01	.01	4.	1.01	17.40	212	.23	.23	.00	135.
1.01	5.45	69	.01	.01	.01	4.	1.01	17.45	213	.23	.23	.00	135.
1.01	5.50	70	.01	.01	.01	4.	1.01	17.50	214	.23	.23	.00	135.
1.01	5.55	71	.01	.01	.01	4.	1.01	17.55	215	.23	.23	.00	135.
1.01	6.00	72	.01	.01	.01	4.	1.01	18.00	216	.23	.23	.00	135.
1.01	6.05	73	.06	.04	.03	16.	1.01	18.05	217	.02	.02	.00	126.
1.01	6.10	74	.06	.04	.03	20.	1.01	18.10	218	.02	.02	.00	113.
1.01	6.15	75	.06	.04	.03	21.	1.01	18.15	219	.02	.02	.00	110.
1.01	6.20	76	.06	.04	.02	22.	1.01	18.20	220	.02	.02	.00	102.
1.01	6.25	77	.06	.04	.02	22.	1.01	18.25	221	.02	.02	.00	96.
1.01	6.30	78	.06	.04	.02	23.	1.01	18.30	222	.02	.02	.00	89.
1.01	6.35	79	.06	.04	.02	23.	1.01	18.35	223	.02	.02	.00	83.
1.01	6.40	80	.06	.04	.02	24.	1.01	18.40	224	.02	.02	.00	73.
1.01	6.45	81	.06	.04	.02	24.	1.01	18.45	225	.02	.02	.00	72.
1.01	6.50	82	.06	.04	.02	25.	1.01	18.50	226	.02	.02	.00	68.
1.01	6.55	83	.06	.04	.02	25.	1.01	18.55	227	.02	.02	.00	63.
1.01	7.00	84	.06	.04	.02	25.	1.01	19.00	228	.02	.02	.00	59.
1.01	7.05	85	.06	.04	.02	26.	1.01	19.05	229	.02	.02	.00	55.
1.01	7.10	86	.06	.04	.02	26.	1.01	19.10	230	.02	.02	.00	51.
1.01	7.15	87	.06	.05	.02	26.	1.01	19.15	231	.02	.02	.00	48.
1.01	7.20	88	.06	.05	.02	27.	1.01	19.20	232	.02	.02	.00	45.
1.01	7.25	89	.06	.05	.02	27.	1.01	19.25	233	.02	.02	.00	42.
1.01	7.30	90	.06	.05	.02	27.	1.01	19.30	234	.02	.02	.00	39.
1.01	7.35	91	.06	.05	.02	27.	1.01	19.35	235	.02	.02	.00	36.
1.01	7.40	92	.06	.05	.01	28.	1.01	19.40	236	.02	.02	.00	34.
1.01	7.45	93	.06	.05	.01	28.	1.01	19.45	237	.02	.02	.00	32.
1.01	7.50	94	.06	.05	.01	28.	1.01	19.50	238	.02	.02	.00	29.
1.01	7.55	95	.06	.05	.01	28.	1.01	19.55	239	.02	.02	.00	27.
1.01	8.00	96	.06	.05	.01	29.	1.01	20.00	240	.02	.02	.00	26.
1.01	8.05	97	.06	.05	.01	29.	1.01	20.05	241	.02	.02	.00	24.
1.01	8.10	98	.06	.05	.01	29.	1.01	20.10	242	.02	.02	.00	22.
1.01	8.15	99	.06	.05	.01	29.	1.01	20.15	243	.02	.02	.00	21.
1.01	8.20	100	.06	.05	.01	29.	1.01	20.20	244	.02	.02	.00	19.
1.01	8.25	101	.06	.05	.01	29.	1.01	20.25	245	.02	.02	.00	18.
1.01	8.30	102	.06	.05	.01	30.	1.01	20.30	246	.02	.02	.00	17.
1.01	8.35	103	.06	.05	.01	30.	1.01	20.35	247	.02	.02	.00	16.

PMF END-OF-PERIOD FLOW

1.01	8.40	104	.06	.05	.01	30.	1.01	20.40	248	.02	.02	.00	15.
1.01	8.45	105	.06	.05	.01	30.	1.01	20.45	249	.02	.02	.00	14.
1.01	8.50	106	.06	.05	.01	30.	1.01	20.50	250	.02	.02	.00	13.
1.01	8.55	107	.06	.05	.01	30.	1.01	20.55	251	.02	.02	.00	12.
1.01	9.00	108	.06	.05	.01	31.	1.01	21.00	252	.02	.02	.00	12.
1.01	9.05	109	.06	.05	.01	31.	1.01	21.05	253	.02	.02	.00	12.
1.01	9.10	110	.06	.05	.01	31.	1.01	21.10	254	.02	.02	.00	12.
1.01	9.15	111	.06	.05	.01	31.	1.01	21.15	255	.02	.02	.00	12.
1.01	9.20	112	.06	.05	.01	31.	1.01	21.20	256	.02	.02	.00	12.
1.01	9.25	113	.06	.05	.01	31.	1.01	21.25	257	.02	.02	.00	12.
1.01	9.30	114	.06	.05	.01	31.	1.01	21.30	258	.02	.02	.00	12.
1.01	9.35	115	.06	.05	.01	31.	1.01	21.35	259	.02	.02	.00	12.
1.01	9.40	116	.06	.05	.01	31.	1.01	21.40	260	.02	.02	.00	12.
1.01	9.45	117	.06	.05	.01	32.	1.01	21.45	261	.02	.02	.00	12.
1.01	9.50	118	.06	.05	.01	32.	1.01	21.50	262	.02	.02	.00	12.
1.01	9.55	119	.06	.05	.01	32.	1.01	21.55	263	.02	.02	.00	12.
1.01	10.00	120	.06	.05	.01	32.	1.01	22.00	264	.02	.02	.00	12.
1.01	10.05	121	.06	.06	.01	32.	1.01	22.05	265	.02	.02	.00	12.
1.01	10.10	122	.06	.06	.01	32.	1.01	22.10	266	.02	.02	.00	12.
1.01	10.15	123	.06	.06	.01	32.	1.01	22.15	267	.02	.02	.00	12.
1.01	10.20	124	.06	.06	.01	32.	1.01	22.20	268	.02	.02	.00	12.
1.01	10.25	125	.06	.06	.01	32.	1.01	22.25	269	.02	.02	.00	12.
1.01	10.30	126	.06	.06	.01	32.	1.01	22.30	270	.02	.02	.00	12.
1.01	10.35	127	.06	.06	.01	32.	1.01	22.35	271	.02	.02	.00	12.
1.01	10.40	128	.06	.06	.01	32.	1.01	22.40	272	.02	.02	.00	12.
1.01	10.45	129	.06	.06	.01	33.	1.01	22.45	273	.02	.02	.00	12.
1.01	10.50	130	.06	.06	.01	33.	1.01	22.50	274	.02	.02	.00	12.
1.01	10.55	131	.06	.06	.01	33.	1.01	22.55	275	.02	.02	.00	12.
1.01	11.00	132	.06	.06	.01	33.	1.01	23.00	276	.02	.02	.00	12.
1.01	11.05	133	.06	.06	.01	33.	1.01	23.05	277	.02	.02	.00	12.
1.01	11.10	134	.06	.06	.01	33.	1.01	23.10	278	.02	.02	.00	12.
1.01	11.15	135	.06	.06	.01	33.	1.01	23.15	279	.02	.02	.00	12.
1.01	11.20	136	.06	.06	.01	33.	1.01	23.20	280	.02	.02	.00	12.
1.01	11.25	137	.06	.06	.01	33.	1.01	23.25	281	.02	.02	.00	12.
1.01	11.30	138	.06	.06	.01	33.	1.01	23.30	282	.02	.02	.00	12.
1.01	11.35	139	.06	.06	.01	33.	1.01	23.35	283	.02	.02	.00	12.
1.01	11.40	140	.06	.06	.01	33.	1.01	23.40	284	.02	.02	.00	12.
1.01	11.45	141	.06	.06	.01	33.	1.01	23.45	285	.02	.02	.00	12.
1.01	11.50	142	.06	.06	.01	33.	1.01	23.50	286	.02	.02	.00	12.
1.01	11.55	143	.06	.06	.01	33.	1.01	23.55	287	.02	.02	.00	12.
1.01	12.00	144	.06	.06	.00	33.	1.02	0.00	288	.02	.02	.00	12.
									SUM	32.50	30.62	1.88	19017.
										(825.)	(778.)	(48.)	(538.50)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1374.	202.	66.	66.	19020.
CMS	39.	6.	2.	2.	539.
INCHES		25.04	32.77	32.77	32.77
MM		636.06	832.24	832.24	832.24
AC-FT		100.	131.	131.	131.
THOUS CU M		123.	162.	162.	162.

SURFACE AREA=	0.	6.	9.	14.	20.	27.
CAPACITY=	0.	48.	114.	228.	397.	630.
ELEVATION=	495.	521.	530.	540.	550.	560.

SUMMARY OF DAM SAFETY ANALYSIS
RATIOS OF PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	521.00	521.00	524.00
STORAGE	48.	48.	66.
OUTFLOW	0.	0.	599.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	523.03	0.00	60.	302.	0.00	15.75	0.00
.90	524.05	.05	67.	621.	.17	15.67	0.00
1.00	524.28	.28	68.	718.	.25	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS
100-YR. FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	521.00	521.00	524.00
STORAGE	48.	48.	66.
OUTFLOW	0.	0.	599.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	521.98	0.00	54.	94.	0.00	12.33	0.00

DAT

ILM